Cancer Incidence in Southington, Connecticut, 1968–1991, in Relation to Emissions from Solvents Recovery Services of New England

Diane D Aye, MPH, PhD (1),* Gary V Archambault, MS (1), Deborah Dumin (2)
(1) Division of Environmental Epidemiology and Occupational Health, Connecticut Department of Public Health, Hartford, CT; (2) Connecticut Department of Environmental Protection, Hartford, CT

Abstract

Data from Southington, Connecticut, were analyzed using geographic information systems (GIS) to explore a possible association between exposure to contaminants from Solvents Recovery Services of New England (SRSNE) and the incidence of selected types of cancer. Data on the incidence of bladder, kidney, liver, and testicular cancer, leukemia, non-Hodgkin's lymphoma (NHL), and Hodgkin's disease were obtained from the Connecticut Department of Public Health Tumor Registry for the period 1968 to 1991. Improper disposal practices by SRSNE caused the air, public drinking water, and soil in Southington to be contaminated. Possible dose-response relationships between exposure to emissions from SRSNE and cancer risk were explored by calculating age and sex standardized incidence ratios (SIR). No statistically significant increase in the SIR was found for cancer of the bladder, kidney, liver, or testis, leukemia, NHL, or Hodgkin's disease for any of the exposure categories when compared with State of Connecticut incidence rates. The total SIR of all tumor sites combined, however, demonstrated a statistically significant increasing trend in relation to increasing exposure to air emissions. Among individual tumor sites, the risk of NHL among females was elevated in locations where the air exposure levels were estimated to be the greatest, although this elevation did not achieve statistical significance. Non-Hodgkin's lymphoma incidence has been increasing during the past several decades with no clear explanation. This study suggests the need for more evaluation of exposure to environmental contaminants and the development of some types of cancer, with specific attention given to NHL.

Keywords: cancer, non-Hodgkin's lymphoma (NHL), solvent exposure, drinking water, air pollution

Background

Solvents Recovery Services of New England (SRSNE) is a National Priority List (NPL) hazardous waste site located in Southington, Connecticut. SRSNE began its solvent recovery operations in 1955. The facility processed between 3 and 5 million gallons of liquid hazardous waste and 100,000 pounds of solid hazardous waste annually.

The SRSNE facility operations included the distillation of recoverable solvents in batch stills with sludges being placed in unlined on-site lagoons for disposal. Improper disposal practices by the company caused the air, public drinking water, and soil in Southington to be contaminated with waste solvents and metals.

* Diane D Aye, Connecticut Dept. of Public Health, 410 Capitol Ave., PO Box 340308, MS#:11CHA, Hartford, CT 06134 USA; (p) 860-509-7742; (f) 860-509-7785; E-mail: diane.aye@po.state.ct.us

The public drinking water wells #4 and #6 are located approximately 1,200 feet south of SRSNE. Well #4 was installed in 1966 and well #6 in 1976. The wells were identified as being contaminated with volatile organic compounds (VOCs) and possibly heavy metals in 1976 and 1977 (1).

Table 1 presents data on the maximum concentrations of contaminants detected from public water supply wells #4, #5, and #6. Well #5 is located approximately 4 miles south of SRSNE and its contamination is not directly site-related. However, SRSNE-generated wastes were disposed of at the Old Southington Landfill (also an NPL site) near well #5. These wells were taken out of production in 1979.

Table 1 Highest Recorded Contamination of Public Water Supply Wells, Southington, CT, 1978 and 1979

Contaminant	Well #4 (ppb)	Well #5 (ppb)	Well #6 (ppb)
Trichloroethylene	120	45	11
1,1 dichloroethylene	210	No data	No data
1,1 dichloroethane	990	No data	No data
t,1,2 dichloroethane	390	6	No data
1,1,1 trichloroethane	33,500	300	120
Tetrachloroethylene	22	No data	No data
Carbon tetrachloride	35	9	No data
Hexane	91	No data	No data
Methane	400	480	130
Methylene chloride	12	No data	No data
Chlorobutane	930	No data	No data
Methyl ethyl ketone	No data	No data	20

ppb = parts per billion
Source: (20)

An on-site open pit incinerator for the burning of solvent and metal sludges operated with no air pollution controls until 1974, when it was taken out of service. Other sources of air pollution included evaporation from the lagoons and storage tanks at the facility, and 25 recovery wells with uncontrolled air strippers.

Methods

Case Ascertainment

Cases of bladder, kidney, liver, and testicular cancer, leukemia, non-Hodgkin's lymphoma, and Hodgkin's disease diagnosed to Southington residents between 1968 and 1991 were mapped using a geographic information system (GIS) and the census block where the case resided at the time of diagnosis was identified. Data on drinking water and air exposure to trichloroethylene (TCE) emissions from SRSNE were estimated and each census block received a relative exposure score (no actual measurements of contaminant levels at case addresses was available). Census blocks with the same

qualitative exposure scores were grouped for analysis. Age and sex standardized incidence ratios (SIRs) were calculated for each tumor site and exposure category to compare the incidence of each cancer in each exposure category with the incidence for Connecticut as a whole.

The tumor sites included in this study were selected based on epidemiological and toxicological studies and community concerns. Epidemiological studies have been conducted that linked populations exposed to drinking water contaminants with bladder cancer, leukemia, and lymphoma (2–15). Toxicological evidence has linked the contaminants with liver and kidney cancer in animals (5,6,16). Testicular cancer was included in the study because citizens in the community expressed concern about testicular cancer incidence.

Preliminary review of the cancer incidence information on these sites is summarized in Table 2. While Southington did not experience an excess of these tumor types when compared with Connecticut state rates, mapping was done on these cases to determine if the incidence of these tumors was increased in areas of the town that were exposed to air or water contamination from SRSNE. Data on cases of cancer occurring in residents of Southington between 1968 and 1991 were obtained from the Connecticut Department of Health (DPH) Tumor Registry. Individual case information includes the patient's residential address at time of diagnosis, primary site of diagnosis, age, sex, and date of diagnosis.

The residential address at time of diagnosis was assigned digital map coordinates using GIS mapping capabilities. Also, during the geocoding process the census block of residence was identified. Mapping of addresses was conducted by the Connecticut Department of Environmental Protection (DEP) with the assistance of an enhanced TIGER file, Dynamap/2000. Each of the addresses was verified against the Southington Assessors maps or by field investigation to ensure accuracy of the geocoding.

Of the 424 cases identified from the registry, 422 cases were geocoded. The remaining two cases could not be geocoded because the address was not listed in the registry records. A map displaying the location of cancer cases in Southington is not presented here in order to protect the confidentiality of the data.

Water Exposure Modeling

The Agency for Toxic Substances and Disease Registry (ATSDR) and the Georgia Institute of Technology hydrologically analyzed the water supply system to determine the geographic areas with the greatest potential for TCE contamination of the drinking water (17). Data on the contaminants identified by water sampling are presented in Table 1. Each census block was assigned a relative water exposure ranking. For example, those census blocks that did not receive public water and relied on private wells that could not have been contaminated with emissions from SRSNE received the lowest exposure rank. Those areas where hydrologic pressure would have been likely to send most of the contaminated water received the highest score. Those census blocks receiving the same exposure score were grouped for analysis.

The Southington Water Company provided information on the location, diameter, and elevation of pipes, and pipe junctures, which was then assigned digital map coordinates by the University of Connecticut's Department of Geography for use in the GIS. The Southington Water Company also provided information on the elevation and location of reservoirs, location of wells, and the proportion and quantity of the water supply

Table 2 Cancer Incidence by Gender, Southington, CT, 1968–1991

	Cancer Incidence in Total Population				Cancer Incidence in Females				Cancer Incidence in Males			
Cancer Type	**OBS**	**EXP**	**SIR**	**95% CI**	**OBS**	**EXP**	**SIR**	**95% CI**	**OBS**	**EXP**	**SIR**	**95% CI**
Bladder	134	131.60	1.02	0.71, 1.33	24	34.27	0.70	0.20, 1.20	110	99.51	1.11	0.74, 1.47
Hodgkin's disease	29	33.91	0.86	0.30, 1.41	8	14.88	0.54	0.00, 1.20	21	19.08	1.10	0.26, 1.94
Kidney	65	71.67	0.91	0.53, 1.29	23	25.02	0.92	0.25, 1.59	42	47.35	0.89	0.41, 1.36
Leukemia	80	85.92	0.93	0.57, 1.29	22	36.24	0.61	0.16, 1.06	58	50.22	1.15	0.63, 1.68
Liver	21	18.10	1.16	0.28, 2.04	10	5.80	1.72	0.00, 3.63	11	12.52	0.88	0.00, 1.80
Non-Hodgkin's lymphoma	80	92.75	0.86	0.53, 1.20	39	44.37	0.88	0.39, 1.37	41	48.62	0.84	0.38, 1.30
Testis	15	20.22	0.74	0.07, 1.41						20.22	0.74	0.09, 1.39
Southington	424	453.11	0.94	0.78, 1.09	126	160.58	0.78	0.54, 1.03	298	296.39	1.01	0.80, 1.21

OBS = Number of observed cancer cases
EXP = Number of expected cancer cases
SIR = Standard incidence ratios
CI = Confidence interval
Source: (20)

provided by these sources over the study period. DPH and the Southington Water Company provided information on water sampling for contaminants in the water distribution system.

The model relied on a US Environmental Protection Agency (EPA) computer software program, EPANET. EPANET tracks the flow of water within each pipe segment, the pressure at each pipe junction, the height of water in each reservoir or storage tank, and the concentration of a contaminant throughout a distribution system (17).

Estimated daily exposure to TCE in the public drinking water was broken into four water exposure categories and is presented in Table 3 and Figure 1. Two-thirds of the town was not impacted by water contamination from SRSNE or the Old Southington Landfill. Water level 1 is the lowest exposure category and 66.4% of the population lived in those portions of town. The areas northeast of the contaminated wells were estimated to receive the highest exposures. Water level 4 is the highest exposure category and no persons lived in this portion of the town. The shape and distance of the geographic areas impacted by water contamination was influenced by water usage, competing sources of water, and the hydrologic pressures in the water distribution system. The relative ranking of exposure to TCE in the drinking water by census blocks enabled the calculation of SIRs based on potential relative exposure to TCE in drinking water.

Table 3 Population and Contaminant Levels of Water Exposure Categories, Southington, CT

Water Exposure Category	Estimated TCE Level per Category (µg/L)	Population[a]	No. of Census Blocks
Southington		36,723	295
Level 1	No exposure	24,374	236
Level 2	1 to <10	7,186	39
Level 3	10 to <50	5,163	18
Level 4	50 or greater	0	2

[a]1980 census figures

µg/L = micrograms per liter

Source: (20)

Air Exposure Modeling

The development of an air contamination model was completed by Robert Tyler of SciTech Corporation of Wethersfield, Connecticut (18), and funded by ATSDR through this project. Air quality modeling of probable TCE emissions from the site was performed using the EPA Industrial Source Complex Long-Term (ISCLT2) model in conjunction with climatological data from the closest National Weather Service station in Hartford. Emission sources were identified through a review of records on SRSNE at the DEP, EPA, and DPH.

Standard emission factors were used to estimate emissions from the solvent reclamation process, and the receiving/storage and blend tanks. Air stripper emissions were calculated using mass balance equations based on groundwater flow rates and concentrations found in the groundwater and effluent. Engineering calculations were used to

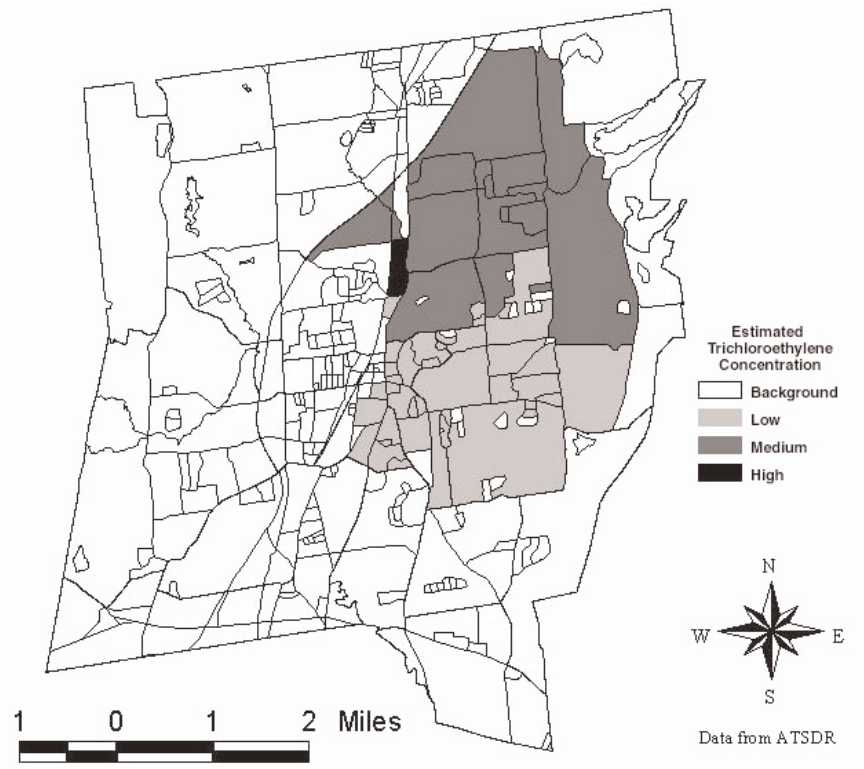

Figure 1 Geographic areas that received contaminated drinking water, Southington, CT, 1980.

estimate emissions from the lagoons and pit incineration. Calculations were based on data and equations provided by the EPA.

The overall air impact of TCE was estimated by summing the individual contributions of each of these sources during the study period and then calculating an average level for the 24-year study period. There were fluctuations in the values, and maximum short-term values were not calculated. TCE was chosen as the indicator pollutant to provide an estimate of the geographic area that was impacted by air emissions from SRSNE. There were, however, many other compounds that were handled by SRSNE that have the potential to be human carcinogens.

The modeling of air releases from SRSNE resulted in Southington being divided into four air exposure categories, which are presented in Table 4 and Figure 2. The majority of the town was not impacted by air emissions from SRSNE. Air level 1 is the lowest exposure category and those areas combined to account for 71% of the Southington population. The areas in closest geographic proximity to the site received the highest exposures. Air level 2 and level 3 combine to account for 29% of the Southington population. Air level 4 is the highest exposure category and no persons lived in this portion of the town. The shape and distance of the geographic areas impacted by emissions was influenced by the topography of the area and the prevailing winds.

Estimates of the Population at Risk

To calculate the SIRs, an estimate of the population at risk was made. The 1980 STF1b

tape from the US Bureau of the Census was used to provide age-specific information for each census block. The 1980 census was chosen for the population estimate because it was the midpoint of the study period. The census blocks with the same exposure scores

Table 4 Population and Contaminant Levels of Air Exposure Categories, Southington, CT

Water Exposure Category	Estimated TCE Level per Category (μg/m³)	Population[a]	No. of Census Blocks
Southington		36,723	295
Level 1	less than 0.01	25,895	200
Level 2	0.01 to <0.015	5,585	46
Level 3	0.015 to <0.10	5,243	46
Level 4	0.10 or greater	0	3

[a]1980 census figures

μg/m³ = micrograms per cubic meter

Source: (20)

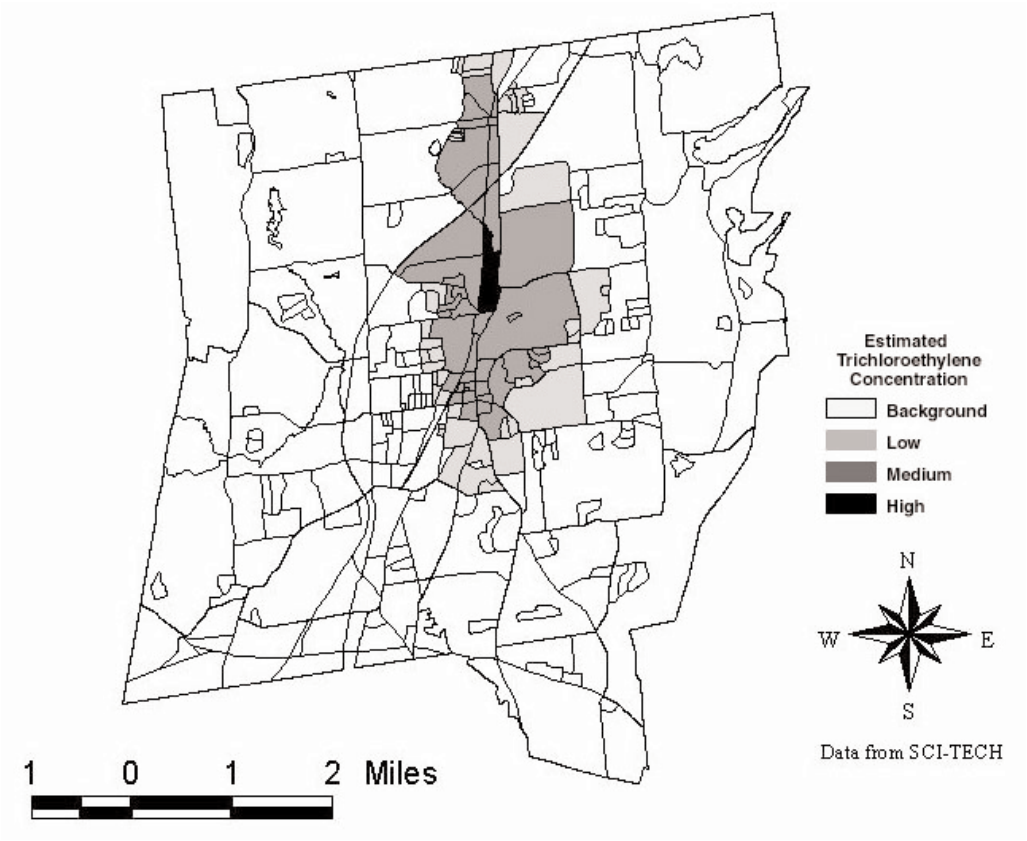

Figure 2 Geographic areas exposed to air emissions from solvents recovery systems of New England, Southington, CT, 1980.

were summed to derive population estimates for the various air and water exposure categories.

Analysis

The indirect method of age standardization and State of Connecticut incidence rates from the DPH Tumor Registry were used to calculate age SIRs. SIRs were calculated for each tumor site and all of the tumor sites combined for each drinking water and air exposure ranking. The indirect rather than direct method of age standardization was chosen for these analyses because the number of cases was small, resulting in incidence rates that would be too unstable for age standardization using the direct method. A Bonferroni correction was made to adjust for multiple comparisons (19).

Results

No statistically significant increase in the SIR was found for cancer of the bladder, kidney, liver, or testis, leukemia, NHL, or Hodgkin's disease for any of the exposure categories when compared with State of Connecticut incidence rates. The total SIR of all tumor sites combined demonstrated a statistically significant increasing trend in relation to increasing exposure to air emissions. For males and females combined, the SIRs were as follows (see Table 5):

- Air level 1: SIR=0.89 (95% confidence interval, 0.70, 1.08)
- Air level 2: SIR=0.99 (95% CI, 0.62, 1.37)
- Air level 3: SIR=1.04 (95% CI, 0.62, 1.47)

Among individual tumor sites, the risk of NHL among females was elevated in locations where the air exposure levels were estimated to be the greatest. Among females, the SIRs were as follows (see Table 6):

- Air level 1: SIR=0.59 (95% CI, 0.09, 1.09)
- Air level 2: SIR=0.59 (95% CI, 0.00, 1.50)
- Air level 3: SIR=2.42 (95% CI, 0.37, 4.46)

The elevation of risk was not consistently shown among males.

The results of the study are presented in more detail in the complete report of the study (20).

Discussion

This study was conducted in response to citizen concerns that persons living in neighborhoods near the SRSNE Superfund site were experiencing higher rates of cancer than was the general population. It was known that these persons had been exposed to emissions from SRSNE, but it was less clear whether the rate of cancer was higher among them than would normally be expected.

Traditionally, cancer rates are calculated for geographic areas with specific political boundaries such as a state or town. Use of a GIS allows disease rates to be calculated at a smaller geographic level. In this study the census block is the unit of analysis.

The GIS was used to improve the exposure assessment and locate each case on a map (geocoding). The mechanization of the geocoding process by the GIS allowed the study to be conducted in a more efficient manner than would have been possible with

Table 5 Cancer Incidence by Gender for Air Exposure Categories, Southington, CT, 1968–1991

	Cancer Incidence in Total Population				Cancer Incidence in Females				Cancer Incidence in Males			
Cancer Type	**OBS**	**EXP**	**SIR**	**95% CI**	**OBS**	**EXP**	**SIR**	**95% CI**	**OBS**	**EXP**	**SIR**	**95% CI**
Southington	424	453.11	0.94	0.78, 1.09	126	160.58	0.78	0.54, 1.03	298	296.39	1.01	0.80, 1.21
Air level 1	265	298.41	0.89	0.70, 1.08	73	105.13	0.69	0.41, 0.98	192	196.21	0.98	0.73, 1.22
Air level 2	84	84.53	0.99	0.62, 1.37	27	30.28	0.89	0.29, 1.49	57	54.90	1.04	0.56, 1.52
Air level 3	73	70.17	1.04	0.62, 1.47	26	25.17	1.03	0.33, 1.74	47	45.27	1.04	0.51, 1.57
Air level 2+3 (any air exposure)	157	154.70	1.01	0.73, 1.30	53	55.45	0.96	0.50, 1.41	104	100.18	1.04	0.68, 1.39

OBS = Number of observed cancer cases
EXP = Number of expected cancer cases
SIR = Standard incidence ratios
CI = Confidence interval
Source: (20)

Table 6 Incidence of Non-Hodgkin's Lymphoma (NHL) by Gender for Air Exposure Categories, Southington, CT, 1968–1991

	NHL Incidence in Total Population				NHL Incidence in Females				NHL Incidence in Males			
	OBS	**EXP**	**SIR**	**95% CI**	**OBS**	**EXP**	**SIR**	**95% CI**	**OBS**	**EXP**	**SIR**	**95% CI**
Southington	80	92.75	0.86	0.53, 1.20	39	44.37	0.88	0.39, 1.37	41	48.62	0.84	0.38, 1.30
Air level 1	44	61.08	0.72	0.34, 1.10	17	28.79	0.59	0.09, 1.09	27	32.45	0.83	0.27, 1.39
Air level 2	13	17.34	0.75	0.02, 1.48	5	8.54	0.59	0.00, 1.50	8	8.85	0.90	0.00, 2.02
Air level 3	22	14.33	1.54	0.39, 2.68	17	7.03	2.42	0.37, 4.46	5	7.32	0.68	0.00, 1.75
Air level 2+3 (any air exposure)	35	31.67	1.11	0.45, 1.76	22	15.57	1.41	0.39, 2.46	13	16.17	0.80	0.03, 1.58

OBS = Number of observed cancer cases
EXP = Number of expected cancer cases
SIR = Standard incidence ratios
CI = Confidence interval
Source: (20)

mapping the location of the cases manually. This enabled the evaluation of whether there was an association between exposure to emissions through the air or public drinking water and the incidence of selected types of cancer.

Census block areas with the same relative exposure rankings were grouped for analysis. Air and water exposures were evaluated separately. Age SIRs were calculated for each tumor site by gender and by relative measure of exposure to TCE emissions in the air and the drinking water. No statistically significant increase in the SIR was found for cancer of the bladder, liver, kidney, or testis, leukemia or Hodgkin's disease for any of the exposure categories when compared with the state of Connecticut. For the total of all tumor sites combined, there was an increase in the SIR for increasing exposure to air contaminants.

The rate of NHL among females was elevated where the air emission rates were estimated to be the highest, although this increase did not achieve statistical significance. Seventeen cases of NHL were diagnosed among women where seven cases would have been expected to occur during this same time period. A similar elevation did not occur among men.

Non-Hodgkin's lymphoma has been increasing dramatically over the past several decades with no clear explanation for the increase. A review of the epidemiology of NHL in Connecticut documented not only the increase in NHL, but also that the histology of the tumors is tending to change. Proportionally, more cases of nodular NHL are occurring. The ratio of diffuse cell type to nodular cell type among women had decreased from 9:1 to about 3:1 from the 1960s to the 1980s (21). Of the 17 women with NHL in the high air exposure area, only 9 had diffuse cell type and 8 had nodular cell type (ratio of 1.1:1). For cases of NHL among women in the unexposed portion of town, 18 had diffuse cell type and only 4 of the 22 cases had nodular cell type (ratio of 4.5:1). Therefore, in the higher air exposure area of this study more of the cases among women are nodular NHL, the same histology of NHL that is increasing in incidence in Connecticut. Previous studies of environmental contamination have shown associations between exposure to solvents and incidence of NHL (14).

These data suggest that women living in the portion of town exposed to emissions from SRSNE through the public water distribution system and the air did experience an increased risk of NHL. Women may have been at their home for a higher portion of the day and therefore experienced a higher exposure than men. However, this study cannot determine whether or not exposures to emissions from SRSNE in the air or water caused any cases of NHL or any other cancer in the town of Southington.

The increasing incidence of NHL over the past few decades supports the need to conduct additional epidemiological research into the possible role of environmental exposure to solvents as a possible risk factor in the development of NHL.

This study of cancer incidence in Southington, Connecticut, has several limitations. While it does use cancer incidence information from the Tumor Registry, these data contain only limited individual data including gender, date of birth, and date of diagnosis. Other relevant risk factors including smoking, family history, and occupation are not routinely available. While Tumor Registry case ascertainment is considered to be very complete, people could have been exposed and then moved from the area prior to diagnosis of their disease.

The population estimates for calculation of the risk measurements were derived from the 1980 census data and do not take growth of the population or migration into

consideration. The population of Southington has grown from 30,746 in 1970, to 36,879 in 1980, to 38,501 in 1990. The 1980 date was selected because it represents the midpoint of the study period.

It must be kept in mind that as an ecological study design this can only be considered hypothesis generating, and that this type of study is not intended to demonstrate a causal relationship (22).

The air exposure estimates are derived from actual chemical use information from the EPA, DEP, and SRSNE company records. Engineering assumptions are used, however, to estimate the amount of TCE released into the air, and average meteorological conditions are used to assist in the estimation of the TCE dispersion.

The water exposure estimates are derived from monitoring data, water usage data, and pipe characteristics. However, water exposure and consumption information for individuals is not known. TCE was modeled as the indicator contaminant because it was found in both the drinking water and air, but it represents only a qualitative indication of the geographic areas in Southington most likely to be impacted by contaminants.

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References

1. Southington Water Company. 1992. Records on water contaminants, water pumping, and pipe characteristics. Southington, CT.
2. Mallin K. 1990. Investigation of a bladder cancer cluster in northwestern Illinois. *American Journal of Epidemiology* 132:s96–s106.0
3. Silverman DT, Hartge P, Morrison AS, Devesa SS. 1992. Epidemiology of bladder cancer. *Journal of Hematology/Oncology Clinics of North America* 6:1–30.
4. Roush GC, Holford TR, Schymura MJ, White C. 1987. *Cancer risk and incidence trends: The Connecticut perspective*. New York: Hemisphere Publishing Co.

5. Agency for Toxic Substances and Disease Registry (ATSDR). 1994. *Toxicological profile for carbon tetrachloride.* Atlanta: US Dept. of Health and Human Services, Public Health Service.
6. Agency for Toxic Substances and Disease Registry (ATSDR). 1993. *Toxicological profile for trichloroethylene*. Atlanta: US Dept. of Health and Human Services, Public Health Service.
7. Banks P. 1990. The pathology of Hodgkin's disease. *Seminars in Oncology* 17:683–95.
8. Urba WJ, Longo DL. 1992. Hodgkin's disease. *New England Journal of Medicine* 236:678–87.
9. Hartge P, Devesa SS, Fraumeni JF. 1994. Hodgkin's and non-Hodgkin's lymphomas. *Cancer Surveys*. 19/20:423–52.
10. Persson B, Fredriksson M, Olsen K, Boeryd B, Axelson O. 1993. Some occupational exposures as risk factors for malignant lymphomas. *Cancer* 72:1773–78.
11. Newell GR, Mills PK, Johnson DE. 1984. Epidemiologic comparison of cancer of the testis and Hodgkin's disease among young males. *Cancer* 54:1117–23.
12. Lagakos SW, Wessen BJ, Zelen M. 1996. An analysis of contaminated well water and health effects in Woburn, Massachusetts. *Journal of the American Statistical Association* 81:583–96.
13. Fagliano J, Berry M, Bove F, Burke T. 1990. Drinking water contamination and the incidence of leukemia: an ecologic study. *American Journal of Public Health* 80:1209–12.
14. Cohen P, Klotz J, Bove F, Berkowitz M, Fagliano J. 1994. Drinking water contamination and the incidence of leukemia and non-Hodgkin's lymphoma. *Environmental Health Perspectives* 102:556–61.
15. Stuver SO, Trichopoulos D. 1994. Liver cancer. *Cancer Surveys* 19/20:99–124.
16. Agency for Toxic Substances and Disease Registry (ATSDR). 1995. *Draft toxicological profile for benzene*. Atlanta: US Dept. of Health and Human Services, Public Health Service.
17. Agency for Toxic Substances and Disease Registry (ATSDR). 1994. *A public health analysis of exposure to contaminated municipal water supplies at Southington, Hartford County, CT*. Atlanta: US Dept. of Health and Human Services, Public Health Service. 20 December.
18. Tyler R. 1994. *Evaluation of the carcinogenic air impacts from Solvents Recovery Services of New England*. SciTech Corporation. September.
19. McClave J, Dietrich FH. 1988. *Statistics.* San Francisco: Dellen Publishing Co.
20. Aye D, Archambault G. 1998. *Cancer incidence in Southington, CT, 1968–1991, in relation to emissions from Solvents Recovery Services of New England.* US Dept. of Health and Human Services.
21. Zheng T, Mayne ST, Boyle P, Holford TR, Liu WL, Flannery J. 1992. Epidemiology of non-Hodgkin lymphoma in Connecticut, 1935–1988. *Cancer* 70:840–9.
22. Walter SD. 1991. The ecologic method in the study of environmental health; I: Overview of the method. *Environmental Health Perspectives* 94:61–73.